RESEARCH PAPER

# Importance of seafood as nutrient source in the diet of Belgian adolescents

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## Abstract

**Background** Regular seafood consumption is recommended in dietary guidelines. The aim of this study was to investigate the importance of seafood as a nutrient source in adolescents' diet and the extent to which seafood consumption can increase the intake of omega-3 polyunsaturated fatty acids and vitamin D.

**Methods** Consumption data recorded during seven consecutive days for 341 adolescents selected in Ghent (Belgium) were used to estimate the intake of vitamin D, linoleic (LA), α-linolenic (LNA), arachidonic (AA), eicosapentaenoic (EPA), docosapentaenoic (DPA) and docosahexaenoic (DHA) acid.

**Results** The adolescents consumed on average 3.21 μg/day vitamin D, 11.7 g/day LA and 1.4 g/day LNA. The mean intakes of AA, EPA, DPA and DHA were 83.2, 55.9, 18.4 and 111.4 mg/day respectively. The major source of vitamin D was fortified margarine. Fats and oils were the main sources for LA and LNA. The intake of AA was mainly contributed by meat, poultry and eggs. Fish and seafood contributed for 84.1%, 59.3% and 64.4% respectively for EPA, DPA and DHA.

**Conclusion** Flemish adolescents would benefit from increased seafood consumption, as this would lead to a higher intake of EPA and DHA as well as of vitamin D. Moreover, replacement of foods rich in saturated fat (SFA) by seafood products can help to reduce SFA intake.



 

**Conflict of interests, source of funding and authorship**

The authors declare that they have no conflict of interests.

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I. Sioen carried out the calculations for the intake assessments and the analysis and interpretation of results and wrote the manuscript. C. Matthys helped during the analysis and interpretation of the results. All authors helped during the writing. S. De Henauw and G. De Backer were responsible for the protocol of the study needed to collect the consumption data.

## Introduction

Recommendations to eat fish and other seafood are included in most national dietary guidelines (World Health Organization, 2003), due to the positive health effects related to seafood consumption. Seafood is an important dietary source of proteins of high biological value, vitamin D, vitamin E, iodine and long chain omega-3 polyunsaturated fatty acids (LC n-3 PUFAs), and is low in saturated fatty acids (Sidhu, 2003; Stichting NEVO, 2003; National Public Health Institute of Finland, 2004).

Recent scientific research indicates that the consumption of LC n-3 PUFAs – eicosapentaenoic acid (EPA, C20:5n-3) and docosahexaenoic acid (DHA, C22:6n-3) being the most abundant in human diet – can be associated with several health benefits, e.g. reduction of the risk of coronary heart diseases (CHD), decrease in mild hypertension, prevention of certain cardiac arrhythmias and sudden death (Kris-Etherton *et al.*, 2002, 2003; Sidhu, 2003). Moreover, it appears that LC n-3 PUFAs play a role in the development and function of the brain, the photoreception, and the reproductive system (Kris-Etherton *et al.*, 2002, 2003; Sidhu, 2003). Therefore, an adequate intake of LC n-3 PUFAs is necessary. Fish and seafood are the main natural dietary sources of these LC n-3 PUFAs (Sidhu, 2003). In addition, fatty fish is an important vitamin D source, with other sources being limited, mainly butter and fortified margarine (Lamberg-Allardt, 2006).

From a life-course perspective aimed at preventing and controlling non-communicable diseases (World Health Organization, 2004), it seems desirable to tackle dietary unbalances already during childhood and adolescence. Moreover, it is known that important health-related lifestyles choices, like dietary patterns, are already established during childhood and adolescence. It is therefore vital that young people are guided towards a healthy eating pattern. Knowing that the consumption of seafood can play a role in the prevention of chronic diseases burden and that processes such as atherosclerosis may start during teenage years, it can be stated that creating the habit of regular seafood consumption at younger age can create health benefits favourable now and later.

This study focuses on the importance of seafood consumption in the diet of Belgian adolescents'. As seafood is a rich source of n-3 PUFAs and vitamin D, the intake of those nutrients is investigated in detail and evaluated using the current Belgian recommendations for nutrient intakes (Belgian Health Council, 2003). Moreover, to the authors' knowledge, few intake data for the considered nutrients are available up to now for this subgroup of the Belgian population. The major aim was to investigate the importance of seafood as nutrient source and to explore if increased seafood consumption can be a solution for low intake of n-3 PUFAs and vitamin D.

## Materials and methods

### Population sample

The food consumption data used for this study were collected between March and May 1997

(Matthys *et al.*, 2003). The survey was based on a representative sample of 341 adolescents (129 boys and 212 girls), aged 13–18 years, from the region of Ghent (±250 000 inhabitants) in the Dutch speaking part of Belgium. Different educational options – 'classical' education (mainly theoretical courses) and vocational training (based on practical skills) – were represented in the sample. A 7-day estimated food record method (semi-structured diary) was used to quantify food and nutrient intake. Instructions for the completion of the diary and regular checks for quality and completeness of the diaries were carried out by experienced dietitians. The storage of data on intake of individual food items was very detailed and contained 745 different food items. These data are the most recent available food consumption data on a 7-day basis for Belgian adolescents. Weight of the respondents was measured in a standardized way and completed in the same period (within 1 week) as the diary. The study was approved by the Ethical Committee of the Ghent University Hospital. Written consent was given by the adolescents and their parents.

## Food composition database

Total fat content of the consumed food items were available from the Belgian food composition database (FCDB) and the Dutch FCDB (NUBEL, 1999; Stichting NEVO, 2001). For this study, food composition data were needed for vitamin D and PUFAs in the food items consumed by the adolescents. For vitamin D, data of the Dutch FCDB were used (Stichting NEVO, 2001), completed with data from the Danish FCDB (Danish Institute for Food and Veterinary Research, 2005) describing the vitamin D intake in seafood items for which data were lacking in the Dutch data source ($n = 5$). In total, 307 of the 745 food items (41.2%) contained vitamin D.

On the other hand, 527 food items (70.6%) contained PUFAs. For those food items, a specific FCDB was developed, including data for total fat, linoleic acid (LA, C18:2n-6), α-linolenic acid (LNA, C18:3n-3), arachidonic acid (AA, C20:4n-6), EPA (C20:5n-3), DPA (C22:5n-3) and docosahexaenoic acid (DHA, C22:6n-3) as they were found in the literature source. Seven existing FCDBs were used for this compilation. In order of quantitative importance, these are: the electronic Dutch FCDB (Stichting NEVO, 2003) (for 404 food items); an extended French FCDB (Astorg *et al.*, 2004) (for 63 food items); the USDA National Nutrient Database (US Department of Agriculture and Agricultural Research Service, 2005) (for 14 food items); the British McCance & Widdowson's FCDB (Food Standards Agency, 2002) (for 11 food items); the Danish FCDB (Danish Institute for Food and Veterinary Research, 2005) (for 11 food items); the Finnish FCDB (National Public Health Institute of Finland, 2004) (for four food items); and the German Food Composition and Nutrition Table (Souci *et al.*, 2000) (for two food items). Furthermore, food composition information from food producers was used for 18 food items, mostly specific varieties of margarine, cheese and dressings.

Detailed fatty acid profiles of the fat containing food items were then calculated using the above mentioned databases by applying the proportional share of each fatty acid in the database of origin to the total fat content of the food as listed in the local FCDB (NUBEL, 1999; Stichting NEVO, 2001).

## Statistics

Average nutrient and food intakes were calculated as the mean of the 7-day intake period. Statistical analysis was done with the SPSS software version 12.0 (SPSS, Inc., Chicago, IL, USA). A Kolmogorov–Smirnov test was used to test for normality ($P$-value < 0.01). A non-parametric test (Mann–Whitney $U$-test) was used to determine differences between the seafood consumption and nutrient intakes of boys and girls; a $P$-value of <0.01 was taken to reduce the probability of false-positive findings.

The percentages of individual PUFAs that are provided by the different food items were calculated as population proportions and as mean proportions, as defined by Krebs-Smith *et al.* (1989). The population proportion is calculated by summing the amount of a fatty acid (FA) from a certain food item for all individuals and then dividing that by the sum of that FA from all food

items for all individuals. The mean proportion of a FA from a certain food item for all individuals is determined by first calculating the contribution of a food item to the intake of that FA for each person and then taking an arithmetic mean of all proportions. The food items were grouped in 36 different subgroups and eight different major groups. The food groups were based on the groups presented by Astorg *et al.* (2004). A Mann–Whitney *U*-test was used to look for significant differences between boys and girls in the contributions of different food groups to the nutrient intake (calculated as mean proportion).

In order to study in detail the contribution of food items to the intake of vitamin D (in $\mu$g/day) on the one hand, and EPA plus DHA (in mg/day) on the other hand, the study population was divided in tertiles based on the intake of the considered nutrients. This division was done separately for boys and girls. A non-parametric test (Kruskal–Wallis test) was used to test the importance of the different food groups between tertiles ($P$-value $< 0.01$).

## Results

The seafood consumption of the whole adolescent population and the consumers only is summarized in Table 1. The latter were defined as the group of adolescents consuming seafood during the 7-day period of the study. From the 341 respondents, 63.9% did consume seafood during the week of the study, respectively 81 boys and 137 girls (Table 1). The weekly amount of seafood consumption for boys was higher than for girls, but not significantly different. The mean seafood eating occasions per week was 1.14, with a maximum of five times a week. In total, 32 different seafood species and two seafood products (caviar and surimi) were consumed by the adolescents. The most important species were cod, saithe and pollack, and salmon, accounting for more than half of the amount of seafood consumed.

The intakes of vitamin D (in $\mu$g/day as in $\mu$g/kJ/day) and individual PUFAs [in mg/day as in percentage of total energy intake (%E)] are given in Table 2. The vitamin D intake was significantly higher for boys compared with girls when expressed in $\mu$g/day ($P < 0.001$); after dividing the vitamin D intake by the energy intake, no significant difference was found between both genders.

The mean intake of LA and LNA was 11.7 and 1.4 g/day respectively. As a consequence, the mean LA/LNA ratio was fairly high: 9.1 on average (Table 2). The mean ratio of the total n-6 PUFA intake ($\sum$n-6PUFA, calculated as the sum of LA and AA) over the total n-3 PUFA intake ($\sum$n-3PUFA, calculated as the sum of LNA, EPA, DPA and DHA) was 8.1. The 5th and 95th percentiles of this ratio confirmed a quite high variation. For the LC PUFAs, the median intakes were much lower than the mean intakes (Table 2), as their intake is skewed. In fact, normality was tested for vitamin D and for the PUFA intake expressed in mg/day as in %E. Only the intake of LA and $\sum$n-6PUFA expressed in mg and in %E, the intake of LNA expressed in mg, and the ratio of $\sum$n-6PUFA over $\sum$n-3PUFA seemed to be normal distributed ($P > 0.01$). For the PUFA intakes, significant differences were found between boys and girls for LA, LNA, AA, $\sum$n-6PUFA and $\sum$n-3PUFA ($P < 0.01$) when expressed in g/day, with the intakes of the boys higher than of the girls (data not shown). When comparing the intakes expressed

**Table 1** Seafood consumption of the whole adolescent population (g/week) and the subpopulation of seafood consumers only

| | Seafood consumption (g/week) | | | | | |
|---|---|---|---|---|---|---|
| | Whole population | | | Seafood consumers only | | |
| | All ($n$ = 341) | Boys ($n$ = 129) | Girls ($n$ = 212) | All ($n$ = 218; 64%) | Boys ($n$ = 81; 63%) | Girls ($n$ = 137; 65%) |
| Mean | 106.8 | 119.5 | 99.0 | 167.0 | 190.2 | 153.3 |
| 25th percentile | 0.0 | 0.0 | 0.0 | 65.0 | 80.7 | 50.0 |
| Median | 55.0 | 70.0 | 48.8 | 148.0 | 150.0 | 125.0 |
| 75th percentile | 183.0 | 184.5 | 184.0 | 221.0 | 226.3 | 219.5 |

| | Mean | P5 | Median | P95 | Belgian RDA |
|---|---|---|---|---|---|
| Vitamin D ♂ (μg/day) | 4.0 | 1.8 | 3.6 | 7.6 | 5.0 |
| Vitamin D ♂ (μg/kJ/day) | 0.37 | 0.19 | 0.35 | 0.64 | |
| Vitamin D ♀ (μg/day) | 2.5 | 1.3 | 2.5 | 4.9 | 5.0 |
| Vitamin D ♀ (μg/kJ/day) | 0.35 | 0.18 | 0.33 | 0.56 | |
| LA (g/day) | 11.7 | 5.8 | 11.1 | 20.0 | |
| LA (%E) | 4.77 | 3.03 | 4.67 | 7.04 | > 2.0 |
| LNA (g/day) | 1.4 | 0.5 | 1.3 | 2.7 | |
| LNA (%E) | 0.57 | 0.29 | 0.52 | 1.00 | > 1.0 |
| AA (mg/day) | 83.2 | 22.7 | 68.9 | 195.7 | |
| AA (%E) | 0.04 | 0.01 | 0.03 | 0.08 | |
| EPA (mg/day) | 55.9 | 0.6 | 25.4 | 244.2 | |
| EPA (%E) | 0.02 | 0.00 | 0.01 | 0.09 | |
| DPA (mg/day) | 18.4 | 0.7 | 9.6 | 62.5 | |
| DPA (%E) | 0.01 | 0.00 | 0.00 | 0.03 | |
| DHA (mg/day) | 111.4 | 10.2 | 72.4 | 363.2 | |
| DHA (%E) | 0.05 | 0.00 | 0.03 | 0.15 | |
| EPA&DHA (mg/day) | 167.3 | 11.2 | 96.9 | 603.0 | |
| EPA&DHA (%E) | 0.07 | 0.01 | 0.04 | 0.26 | > 0.3 |
| ∑n-6PUFA (g/day) | 11.8 | 5.8 | 11.2 | 20.3 | |
| ∑n-6PUFA (%E) | 4.89 | 3.14 | 4.76 | 7.17 | 4.0–8.0 |
| ∑n-3PUFA (g/day) | 1.6 | 0.6 | 1.5 | 3.0 | |
| ∑n-3PUFA (%E) | 0.66 | 0.32 | 0.61 | 1.16 | 1.3–2.0 |
| LA/LNA | 9.1 | 5.2 | 8.7 | 14.4 | |
| ∑n-6PUFA/∑n-3PUFA | 8.1 | 4.5 | 7.8 | 12.7 | |

**Table 2** Intake of vitamin D (μg/day and μg/kJ/day) and individual PUFAs (mg/day) and % of total energy intake (%E), ratio of the intake of LA versus LNA as well as of the intake of ∑n-6 PUFA versus ∑n-3 PUFA, and the recommended daily allowances (RDA) of vitamin D and fatty acids, formulated by the Belgian Health Council (2003) (expressed in μg/day or % of total energy intake)

∑n-6PUFA = LA + AA; ∑n-3PUFA = LNA + EPA + DPA + DHA; P5: 5th percentile; P95: 95th percentile.
LA, linoleic; LNA, α-linolenic; AA, arachidonic; EPA, eicosapentaenoic; DPA, docosapentaenoic; DHA, docosahexaenoic; ∑n-3PUFA, omega-3 polyunsaturated fatty acids.

as %E, no significant differences were detected (all *P*-values > 0.01). This is explainable by the correction made by using the energy intake that was significantly higher in boys (10625 kJ) when compared with girls (8030 kJ) (Matthys *et al.*, 2003).

Table 3 shows the proportional contribution of the different food groups to vitamin D and PUFA intake, calculated as population proportions. The major sources of vitamin D were fats and oils, with margarines as most important subgroup. Other important contributors were meat, poultry and eggs, fish and seafood, and prepared potatoes (e.g. mashed potatoes, containing eggs).

Fats and oils were the main sources for LA, followed by cereal products. In the group of fats and oils, margarines and fatty sauces (dressings, etc.) were the major sources. In the group of cereal products, bread and rusks were most important. The intake of AA was mainly contributed by meat, poultry and eggs. For LNA, a quite similar result as for LA was found, with fats and oils being the major contributors, followed by cereal products. In contrast, where dairy products were of negligible importance for the LA intake, they counted for 5.6% for the LNA-intake, with cheese being the most important subgroup. For the three different LC n-3 PUFAs, fish and seafood contributed for 84.1%, 59.3% and 64.4% respectively for EPA, DPA and DHA. The most important subgroup was fatty fish. For EPA, molluscs and crustacean were also quite important. A substantial part of the DPA intake was contributed by poultry, meat and meat dishes, and eggs. They contributed also to the DHA intake, with poultry as major subgroup. The contribution of each food group to the nutrient intake was also calculated on individual level and then compared between boys and girls (data not shown). No relevant differences were found on that level. More detailed information about the actual consumption of the different food groups can be found in Matthys *et al.* (2006).

Table 4 indicates the energy and fat intake and the consumption of some relevant food items for the tertiles based on the vitamin D and EPA&DHA

**Table 3** Contribution of food groups to vitamin D (vit D), n-6 and n-3 PUFA intakes (% of the total intake of each FA brought by each food group for the whole population)

| Food groups | Vit D | LA | LNA | AA | EPA | DPA | DHA | ∑n-6 PUFA | ∑n-3 PUFA |
|---|---|---|---|---|---|---|---|---|---|
| Bread and rusks | 0.12 | 18.21 | 12.97 | 0.00 | 0.00 | 0.00 | 0.00 | 18.08 | 11.45 |
| Breakfast Cereals | 0.00 | 0.51 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.51 | 0.18 |
| Cereal based dishes | 1.30 | 1.25 | 1.77 | 0.75 | 0.00 | 0.00 | 0.17 | 1.24 | 1.57 |
| Pasta, rice and other cereals | 0.73 | 1.77 | 1.12 | 0.32 | 0.02 | 0.00 | 0.00 | 1.76 | 0.99 |
| Total cereal products | 2.16 | 21.74 | 16.06 | 1.07 | 0.02 | 0.00 | 0.17 | 21.59 | 14.18 |
| Butter | 0.69 | 0.16 | 0.64 | 0.68 | 0.00 | 0.00 | 0.00 | 0.16 | 0.56 |
| Cheese | 4.90 | 1.02 | 3.56 | 2.22 | 0.00 | 0.00 | 0.00 | 1.03 | 3.14 |
| Cream | 0.34 | 0.05 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.15 |
| Milk | 0.82 | 0.37 | 1.08 | 0.42 | 0.00 | 0.00 | 0.00 | 0.37 | 0.95 |
| Yogurts | 0.24 | 0.05 | 0.16 | 0.02 | 0.00 | 0.00 | 0.00 | 0.05 | 0.14 |
| Total dairy products | 7.00 | 1.65 | 5.60 | 3.34 | 0.00 | 0.00 | 0.00 | 1.66 | 4.94 |
| Fatty sauces | 0.44 | 10.54 | 32.86 | 0.00 | 0.44 | 0.00 | 0.00 | 10.47 | 29.01 |
| Margarines | 36.43 | 19.23 | 15.25 | 0.00 | 0.00 | 0.00 | 0.00 | 19.09 | 13.45 |
| Mixed fats | 0.02 | 5.15 | 0.08 | 0.02 | 0.00 | 0.00 | 0.00 | 5.11 | 0.07 |
| Vegetable oils | 0.00 | 8.55 | 0.82 | 0.00 | 0.00 | 0.00 | 0.00 | 8.49 | 0.73 |
| Total fats and oils | 36.89 | 43.47 | 49.00 | 0.02 | 0.44 | 0.00 | 0.00 | 43.16 | 43.25 |
| Fatty fish | 8.28 | 0.21 | 0.44 | 1.23 | 42.36 | 40.68 | 29.87 | 0.21 | 4.47 |
| Fish products | 1.45 | 0.21 | 0.07 | 0.47 | 4.62 | 2.28 | 4.02 | 0.21 | 0.54 |
| Half-fatty fish | 0.58 | 0.03 | 0.05 | 0.73 | 4.28 | 3.51 | 9.39 | 0.04 | 0.90 |
| Lean fish | 2.57 | 0.01 | 0.03 | 2.09 | 17.17 | 8.51 | 16.56 | 0.02 | 1.90 |
| Molluscs and crustaceans | 0.27 | 0.01 | 0.03 | 3.16 | 15.68 | 4.29 | 5.55 | 0.03 | 1.02 |
| Total fish and seafood | 13.15 | 0.46 | 0.62 | 7.68 | 84.11 | 59.27 | 65.40 | 0.51 | 8.83 |
| Fruits | 0.00 | 0.03 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.28 |
| Legumes | 0.00 | 0.02 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.12 |
| Nuts and seeds | 0.00 | 1.42 | 0.45 | 0.00 | 0.02 | 0.00 | 0.00 | 1.41 | 0.40 |
| Potatoes | 12.72 | 0.06 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.18 |
| Soups | 0.39 | 0.10 | 0.06 | 0.03 | 0.00 | 0.00 | 0.00 | 0.10 | 0.05 |
| Vegetables | 0.00 | 0.19 | 0.68 | 0.02 | 0.06 | 0.00 | 0.00 | 0.19 | 0.60 |
| Total fruits and vegetables | 13.11 | 1.83 | 1.84 | 0.04 | 0.08 | 0.00 | 0.00 | 1.81 | 1.63 |
| Eggs | 5.25 | 1.29 | 0.41 | 20.43 | 0.34 | 10.22 | 8.54 | 1.42 | 1.10 |
| Meat and meat dishes | 9.65 | 7.61 | 8.25 | 35.59 | 4.29 | 6.78 | 9.03 | 7.80 | 8.15 |
| Poultry | 3.00 | 2.26 | 1.72 | 25.11 | 5.36 | 19.60 | 10.35 | 2.42 | 2.66 |
| Total meat, poultry and eggs | 17.90 | 11.16 | 10.38 | 81.13 | 9.99 | 36.60 | 27.92 | 11.65 | 11.91 |
| Biscuits | 2.38 | 3.51 | 2.68 | 0.27 | 0.00 | 0.46 | 0.07 | 3.49 | 2.38 |
| Chocolate products | 0.53 | 8.39 | 5.77 | 0.00 | 0.00 | 0.00 | 0.00 | 8.34 | 5.09 |
| Pastry and desserts | 5.89 | 2.73 | 3.00 | 4.32 | 0.06 | 0.00 | 1.07 | 2.74 | 2.72 |
| Sugar and sweets | 0.00 | 0.03 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 |
| Total sweet products | 8.80 | 14.66 | 11.47 | 4.60 | 0.06 | 0.46 | 1.14 | 14.59 | 10.21 |
| Miscellaneous | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 |
| Salty snacks | 0.02 | 2.99 | 1.10 | 0.00 | 0.00 | 0.57 | 0.08 | 2.97 | 0.99 |
| Snacks | 0.97 | 1.64 | 3.41 | 2.13 | 5.19 | 3.10 | 5.29 | 1.65 | 3.60 |
| Spices and condiments | 0.00 | 0.09 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.28 |
| Vegetarian substitute | 0.00 | 0.31 | 0.18 | 0.00 | 0.10 | 0.00 | 0.00 | 0.31 | 0.16 |
| Total miscellaneous | 0.99 | 5.04 | 5.03 | 2.13 | 5.30 | 3.67 | 5.36 | 5.02 | 5.05 |

∑n-6PUFA = LA + AA; ∑n-3PUFA = LNA + EPA + DPA + DHA.

intake. The consumption of the food items is expressed in g/day as in contribution to the total energy intake (%E); the latter to correct for the overall energy intake of the individuals. For both genders, higher energy and fat intake as well as higher consumption of margarine and total fats and oils was found for the higher vitamin D tertiles. This was also the case for fatty fish, expressed in g/day (Table 4). Moreover, for the girls, significant differences were found for the consumption of pastry and desserts, potatoes and poultry (in g/day), with a higher consumption for the higher vitamin D tertiles (data not shown). When considering the EPA&DHA tertiles, significant differences were only found for food items belonging to the fish and seafood group, showing

**Table 4** Consumption of different food items [in g/day and in contribution to the total energy intake (%E)] for the different tertiles based on the vitamin D intake and the EPA & DHA intake, separately for boys and girls*

| | | ♂ ($n$ = 120) | | | ♀ ($n$ = 212) | | |
|---|---|---|---|---|---|---|---|
| Tertiles of vitamin D intake ($\mu$g/day) | | < 3.00 | [3.00–4.33] | > 4.33 | < 2.25 | [2.25–3.05] | > 3.05 |
| Energy intake | kJ | **9761** | **10553** | **11937** | **6847** | **8083** | **9122** |
| Fat intake | g/day | **89.6** | **103.5** | **122.8** | **61.2** | **77.3** | **92.0** |
| | %E | **34.5** | **36.9** | **38.7** | **33.4** | **36.1** | **38.0** |
| Margarine | g/day | **8.3** | **16.7** | **36.2** | **6.4** | **11.9** | **20** |
| | %E | **2.4** | **4.2** | **7.4** | **2.5** | **4** | **5.3** |
| Total fats and oils | g/day | **7.8** | **12.7** | **16.6** | **6.4** | **8.5** | **11.6** |
| | %E | **2.3** | **3.4** | **3.7** | 2.7 | 3 | 3.4 |
| Lean fish | g/day | 21.2 | 23.3 | 27.7 | 18.8 | 19.4 | 29.7 |
| | %E | 0.9 | 0.8 | 0.8 | 1 | 1 | 1.3 |
| Half-fatty fish | g/day | 16.5 | 18.6 | 13.7 | 8.2 | 10.4 | 10.6 |
| | %E | 1 | 1.1 | 0.5 | 0.6 | 0.7 | 0.5 |
| Fatty fish | g/day | **7.6** | **8.2** | **22.8** | **5.5** | **7.2** | **22.4** |
| | %E | 0.6 | 0.7 | 1.7 | **0.9** | **0.9** | **2.8** |
| Total fish and seafood | g/day | 14.1 | 15.7 | 20.4 | **11.4** | **13** | **18.8** |
| | %E | 0.7 | 0.9 | 1 | 0.8 | 0.8 | 1.3 |
| Tertiles of EPA&DHA intake (mg/day) | | < 70 | [70–180] | > 180 | < 54 | [54–143.6] | > 143.6 |
| Energy intake | kJ | 10848 | 10537 | 10864 | 7740 | 7924 | 8377 |
| Fat intake | g/day | 105.9 | 104.3 | 105.2 | 73.4 | 75.9 | 80.9 |
| | %E | 36.7 | 37.3 | 36.2 | 35.4 | 35.8 | 36.3 |
| Lean fish | g/day | **6.7** | **17.8** | **31** | **8.3** | **14.4** | **26.2** |
| | %E | **0.2** | **0.6** | **1** | **-** | **0.7** | **1.2** |
| Half-fatty fish | g/day | 2.9 | 14.5 | 17.5 | **3.9** | **8.5** | **11.7** |
| | %E | 0.1 | 0.8 | 0.9 | 0.2 | 0.6 | 0.7 |
| Fatty fish | g/day | **8.2** | **3.6** | **17.8** | **2.1** | **4.9** | **18.7** |
| | %E | **0.5** | **0.3** | **1.4** | **0.3** | **0.7** | **2.3** |
| Molluscs and crustacean | g/day | 3.6 | 6.5 | 12.6 | **3.8** | **7** | **15.9** |
| | %E | 0.1 | 0.2 | 0.4 | **0.2** | **0.4** | **0.7** |
| Fish products | g/day | 15 | 18.5 | 18.5 | 9.7 | 14.9 | 14.4 |
| | %E | 1.2 | 1.4 | 1.3 | 0.9 | 1.3 | 1.3 |
| Total fish and seafood | g/day | **8.3** | **12.9** | **20.1** | **6** | **10** | **18.6** |
| | %E | **0.5** | **0.6** | **1.1** | **0.5** | **0.7** | **1.3** |

For the figures indicated in bold, a significant difference between the tertiles was found ($P$-value < 0.01).
*The amounts consumed of the different food items reported in g/day and in %E are calculated as the mean only for those adolescents that consumed the food item during the week of the study and not as a mean for all members of the tertile. In other words, it is a mean of the consumer population only. As a result, the sum of the mean consumption of the different fish types is not equal to the consumption of total fish & seafood, since a different number of consumers is accounted for.

that higher EPA&DHA intake was related with higher fish and seafood intake; the intake of energy and fat did not differ significantly. For not-mentioned food groups (e.g. fruits and vegetables), no significant differences were found over the different tertiles.

## Discussion

Three methodological shortcomings related to this study have to be mentioned, related to the food consumption data and the food composition data. First, it has to be said that the food consumption data used are rather old (1997). But, no other recent data describing the consumption during seven consecutive days exist at the moment for this subgroup of the Belgian population. The important advantage of consumption data gathered over a longer period involves that they allow assessing the intake of nutrients present in relatively few foods that are not eaten on daily basis, such as seafood (Lamberg-Allardt, 2006).

Second, a weakness of the 7-day estimated food record method is underreporting or underestimation of the food intake. In general, food items rich in fat and/or carbohydrates (such as butter,

sweet products and snacks) are reported less frequently and/or in smaller quantities than actually consumed. This will have an influence e.g. on the margarine consumption and as such on the assessed vitamin D intake. However, there is still no better method available to estimate quantitatively dietary intake on a population basis.

Third, at the level of the food composition data, a limitation of this study is that we did not have our own analytical data for vitamin D and PUFA. Hence, several previously published data were used, but the derivation of this data is unknown. Additionally, it is noticeable that in individual foods PUFAs, in particular the LC PUFAs, are present in only small amounts, but accumulate to significant levels of biological importance in the context of a whole diet. For most foods, these low values often round down to zero when reported on a single decimal place and so it is likely that fatty acid concentrations will be consistently underreported in FCDBs (Mann *et al.*, 2003). Furthermore, for some items it was not evident to find the PUFA composition and seven different databases were needed to determine the PUFA composition of all food items, which is not an ideal situation as different protocols can be hidden behind the data and the origin of the published data was hard to trace for some FCDBs.

The Belgian Health Council advices the population to consume fish one to two times a week (Belgian Health Council, 2004). Moreover, seafood has a prominent place in the Flemish food triangle. Nevertheless, 36.1% of the studied adolescents did not consume any seafood in the week of the study. A more regular replacement of meat & meat products by seafood should, above an increased intake of n-3 PUFAs and vitamin D, also be beneficial to decrease the too high saturated fatty acid (SFA) intake of this studied population, as reported by Matthys *et al.* (2006). Another major contributor to the SFA intake was high-fat cheese, a food item consumed most of the time during bread meals. Replacement of that cheese with seafood like mackerel and sardines can lower the SFA intake and at the same time increase the intake of vitamin D and EPA&DHA. But of course, the food choice of adolescents is mostly driven by taste, smell and convenience, and fish does not have a high preference rate (Diehl, 1999). On the other hand, parents or school catering services make the decision whether or not fish and other seafood will be regularly placed on the menu. In addition, fish and/or seafood allergies or total dislike of fish will influence the actual consumption. In the latter case, other strategies, e.g. fortified foods and supplements, can be used as alternatives to increase the n-3 PUFA intake.

To evaluate the current assessed vitamin D and PUFA intakes, the data are compared with the recommendations formulated by the Belgian Health Council. Nevertheless, these values are recommended daily allowances (RDA) (Belgian Health Council, 2003), and it is debatable whether it would be better to use estimated average requirements when evaluating nutrient intakes at population level. But, currently, these values are not available for the Belgian population.

The mean and median vitamin D intakes of the adolescent boys fall within the recommended range. In contrast, the results showed that half of the studied girls have an intake lower than 2.5 $\mu$g/day. The most important dietary source of vitamin D for the adolescents is margarine, due to the mandatory vitamin D fortification of margarine in Belgium. Food fortification is widely used in many industrialized countries for increasing vitamin D intake (Ovesen *et al.*, 2003). As the consumption of fatty fish is significantly higher for the highest vitamin D tertiles, a lot of girls, and also boys, would benefit from higher fatty fish consumption. On the other hand, it must be taken into account that advising increased consumption of fat-rich food items to increase the vitamin D intake will simultaneously increase the total fat intake. When considering vitamin D, it must also be mentioned that ultraviolet-induced skin production constitutes the main contributor to vitamin D in humans, making oral intake alone nonessential in principal (Sichert-Hellert *et al.*, 2006). In contrast, Ovesen *et al.* (2003) stated that skin synthesis of vitamin D may not compensate for the low-nutritional intake in Europe. Moreover, Lamberg-Allardt (2006) suggested that the recommendation should be increased to be at least 10 $\mu$g/day in all age groups when solar UVB is scarce. In this study population, even the 95th

percentile does not reach this level, with the 95th percentile of the girls being only 4.9 μg/day. Nevertheless, it has to be mentioned that Ricketts disease, the direct consequence of vitamin D deficiency, is not a major public health problem in Belgium. But this does not mean that a long term, too low intake of vitamin D will not create health problems.

The LA and ∑n-6 PUFA intakes fit the Belgian recommendations for the major part of the population (Belgian Health Council, 2003). In contrast, the mean and median intakes of LNA, LC n-3 PUFA and ∑n-3 PUFA fall well below the recommended intake. The recommended minimum is expressed for the sum of EPA and DHA, being at least equal to 0.3%E. Since the median intake for EPA&DHA was 0.04%E, it can be concluded that the study population has an important deficit for these PUFAs. These data were compared to other intake data of (LC) n-6 and n-3 PUFAs for adolescents from Australia [1086 children; 12–18years; one 24-h recall plus a food frequency questionnaire (FFQ); 1995] (Howe *et al.*, 2006) and the USA (581 boys and 536 girls; 14.8 ± 0.02years; one 24-h recall; 2001) (Harel *et al.*, 2001); the latter only describing the intake of n-3 PUFAs. In this context, it must be mentioned that a good comparison of data is hampered as different food composition data and different methodologies to collect food consumption data were used in the different studies. The LA and ∑n-6 PUFA intake was higher in Belgium than in Australia (respectively, 11.7 and 11.8 versus 11.1 and 11.4 g/day). The LNA intake was highest in Belgium, followed by Australia (1.18 g/day) and the USA (0.35 g/day). Nevertheless, the sum of EPA, DPA and DHA was highest in Australia (195.0 mg/day), followed by Belgium (185.7 mg/day) and the USA (38.5 mg/day).

In conclusion, Flemish adolescents would benefit from increased seafood consumption. This can lead to a higher intake of EPA&DHA and vitamin D, nutrients of which the current intake is (very) low, and is also of interest for other nutrients. Moreover, replacement of food sources rich in SFA, like meat products and high fat cheese by seafood products could help to reduce the intake of SFA. But further investigation is necessary to explore the best way to convince adolescents of these health beneficial steps.

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